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Comparative studies of the NMR of thulium in Tm123 and Tm124 compounds: Evidence for structural and electronic phase separation

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Abstract

The nuclear magnetic relaxation of 169Tm in TmBa2Cu3O6+x (x =0.1-1.0, Δx=0.1) and TmBa2Cu4O8 is studied at temperatures below 5 K. In all the samples, the Tm spin-lattice relaxation proceeds via intrinsic paramagnetic centers (PCs) like Cu2+ or copper-oxygen spin-polarized clusters. The experimental data for TmBa2Cu3O6+x support the idea of the structural (chemical) micro-phase separation in oxygen-deficient 123 compounds. Apparently, the samples with x≥0.4 contain hole-poor nonsuperconducting regions, enriched with PCs, and hole-rich (PC-poor) superconducting regions. The volume fraction fn of the PC-rich phase reaches a maximum value of 0.85 at x=0.4 and decreases monotonically with increasing x (fn=0.5, 0.3, and 0.25 at x =0.5, 0.6, and 0.7, respectively). The Tm spin-lattice relaxation in the underdoped TmBa2Cu4O8 compound indicates that this sample, in contrast to oxygen-deficient TmBa2Cu3O6+x, has a homogeneous composition. However, the Tm spin-spin relaxation measurements reveal two sorts of the Tm nuclear spins in Tm124, having different NMR spectra and different relaxation times T2. The latter result is evidence of electronic phase separation in CuO2 phases.